ISSUE 1 / 2011

DATA – FACTS – ANALYSIS

CUTEC-News

CAT AND MOUSE? *

WE WISH YOU ALL THE BEST FOR THE NEW YEAR 2011

Don't wish it were easier, wish you were better.
Don't wish for fewer problems, wish for more skills.
Don't wish for fewer challenges, wish for more wisdom.
Jim Rohn (American business philosopher)

Along with passing on our best wishes for the New Year, we would like to thank you for the positive working relationship over the past year, and we hope that you will continue to place your confidence in us.

We wish you, your families and your employees a healthy and prosperous New Year.

The staff and Senior Management Team at the CUTEC Institute

Prof. Otto Carlowitz
Managing Director

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10 YEAR ANNIVERSARY OF CLAUSTHAL ENERGY PARK

Symposium and Open House

Clausthal Energy Park was at the centre of attention in September. We mentioned on several occasions that two activities had been scheduled to mark the 10th anniversary of the Clausthal Energy Park. A Renewable Energy Symposium was held on Thursday, September 23, 2010 in the CUTEC Lecture Theatre. Saturday, September 25th, 2010 was Open House at the Energy Park in connection with the Science Year 2010 in Germany (The Future of Energy).

Dr. Vodegel opened the Clausthal Energy Park's 10th Anniversary Symposium by welcoming everyone to the event. Dr. Schroeder on behalf of the Lower Saxonian Ministry of Science and Culture, who is the Chairman of the Supervisory Board at CUTEC, also said a few words of welcome, and Prof. Beck from the TU Clausthal, who was and is involved in the Clausthal Energy Park project, greeted the members of the audience. He also took the opportunity to briefly reflect on the origins of the project and its strategic importance for CUTEC and TU Clausthal.

The guest speaker on the day was German MP Hans-Josef Fell from the Green Party, who took a look back at 10 years of renewable energy in Germany. As the energy policy spokesperson for the parliamentary party and one of the authors

View of the Lecture Theatre during the event

of the Renewable Energy Act (EEG) in 2000, he outlined the current energy policy of the German government and voiced criticism with regard to some aspects of that policy. Before beginning his discourse on energy policy, he cited some figures and examples which illustrate the advantages of renewable energy, and he expressed the view that it is not a misguided vision to suggest that we could meet nearly all of our energy needs from renewable sources. His talk gave the audience plenty to discuss during the coffee break which followed.

Mr. Siemers from CUTEC, who is the overall Project Manager, kicked off the second block of talks. He spoke about the start-up phase and the current status of the project after 10 years of operation. After presenting a brief historical insight into the emergence of the idea and the project and thanking everyone involved, Mr. Siemers provided a condensed summary of the project structure and some of the outcomes. Dr. Wehrmann from the Institute of Power Engineering (IEE) at TU Clausthal continued with some insights into specific components and the electrical operational procedures. He cited the results of some of the trials to highlight the issues and problems which are involved in off-grid operations with electrical disturbances.

The next three speakers shared information on further expansion of the project and activities that are a logical extension of what has been achieved so far, highlighting the fact that the Energy Park is not merely an end in itself. Prof Kurrat (TU Braunschweig) explained the idea of the Research Cluster Energy Lower Saxony (FEN) through an example for the grid-dominated operation of Mini CHPs. Some of the trials have been conducted right at the Energy Park. Mr. Miede from E.ON Avacon talked about micro cogeneration from the point of view of an energy supplier. Mrs. Senkel from CUTEC expanded on the same theme, taking the audience into the realm of combined heat, cooling and power. She explained that it is possible to use an absorption chiller to convert excess heat from a CHP into cooling for air-conditioning systems. It is the task of another FEN-project to identify the best approach to this technology.

Following the presentations on the theoretical and practical aspects of the day's theme, Prof. Jischa provided the finishing touch by outlining a vision of tomorrow's energy systems, and as usual he was able to generate great enthusiasm among his listeners. A number of people, who were asked for their opinion about the day's proceedings, were highly complimentary. Following the symposium, the visitors toured the Energy Park, and the day ended in a relaxed atmosphere at an enjoyable get-together.

The audience listened attentively to speaker Hans-Josef Fell (at the podium)

The general public had the opportunity to learn more about energy on the following Saturday. BMBF* had declared September 25th as Energy Day on the Year of Science 2010 calendar. CUTEC acted as a partner in this campaign. As they toured the Park, the visitors were asked to collect kWh, and they also took a first-hand look at different forms of energy. (sie)

*BMBF: Federal Ministry of Education and Research

CAT AND MOUSE?

Deployment of oxidation catalysts on existing regenerative thermal off-gas purification units for the purpose of reducing fuel consumption

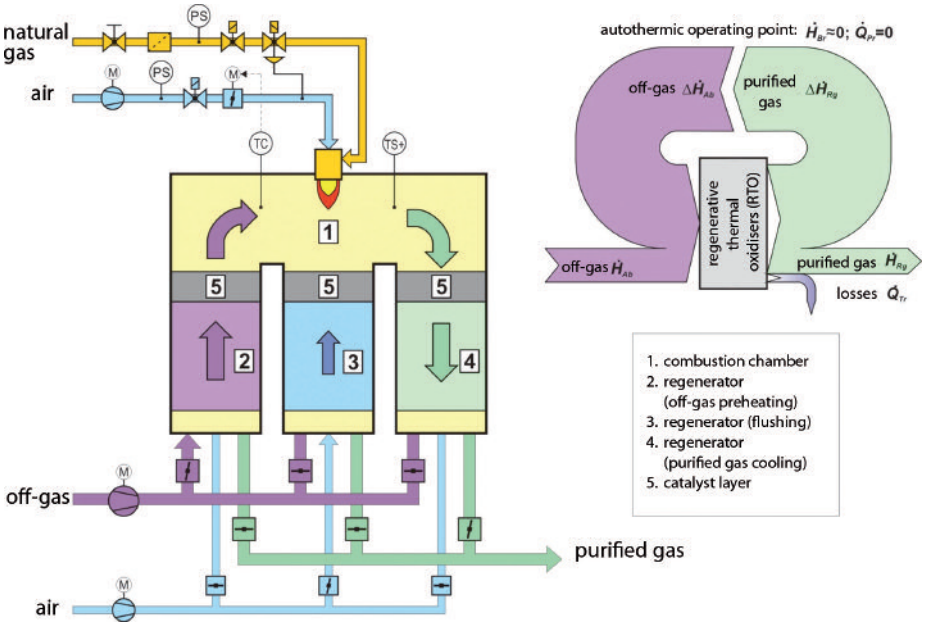

Fig. 1 Basic design of an RTO (left), and an energy flow diagram for the autothermic operating point (re.)

Initial scenario and project approach

This project received AiF funding under the umbrella of the SME Innovation (ZIM) programme. The goal was to develop a process which makes it feasible to retrofit catalytic oxidisers on existing regenerative thermal oxidisers (RTO) in order to significantly reduce auxiliary fuel consumption and the associated CO_2 emissions. The result of the process to control toxic emissions remains unchanged. Thermal oxidation technologies are used to control VOC and solvent emissions. Oxidation converts toxic VOCs into non-toxic compounds at around 800°C. Regenerators pre-heat the off-gas, reducing auxiliary fuel consumption. New regenerative catalytic plants (RCOs) are now available on the market, but retrofitting existing plants with catalytic oxidation and the associated combustion systems is an attractive option from the cost standpoint, partly because most of the installed equipment can be retained which significantly reduces the size of the investment needed.

Three companies have formed an engineering alliance to develop the technology. The project responsibilities have been allocated as follows: development of a new combustion system (KG ELBE-Gas-Anlagenbau), overall system simulation (CUTEC) and definition of the design and assessment criteria (Allog Engineering). RTO systems similar to Figure 1 have been used for emission control in Germany since 1984.

On RTO systems, ceramic beds which are periodically switched over preheat the off-gas. In Figure 1, regenerator (2) preheats the off-gas and regenerator (4) cools the purified gas while regenerator (3) is flushed with fresh air. This prevents any VOC residue left in the regenerator from contaminating the purified gas when the chamber is switched over from off-gas to purified gas. A burner feeds the fuel, which is needed to raise the temperature to the required level, into the combustion chamber (1). If there is sufficient chemical energy bound up in the VOCs, the system runs in autothermic mode. After installation of a regenerative catalytic oxidiser (item 5 in Figure 1), the reaction temperature decreases, reducing fuel consumption. This presupposes that, for example, the off-gas does not contain any significant amount of catalyst poisons. It must be possible to revert to thermal-only mode should the need arise.

The savings potential is shown in Figure 2. If the catalysts can reduce the reaction temperature from 850 °C to 350 °C at an off-gas inlet temperature of 100 °C, the rise in temperature which must be provided by burning the fuel decreases by 80%.

Engineering and business risks

The project is based on the assumption that an existing RTO is already in place. It will be possible to revert to thermal-only operation, reducing the risk to the user. However, this does not reduce the risk incurred by the retrofit supplier. The methodology is new, and it is not something that RTO system suppliers will put at the top of their marketing agenda, because their main interest is to sell new

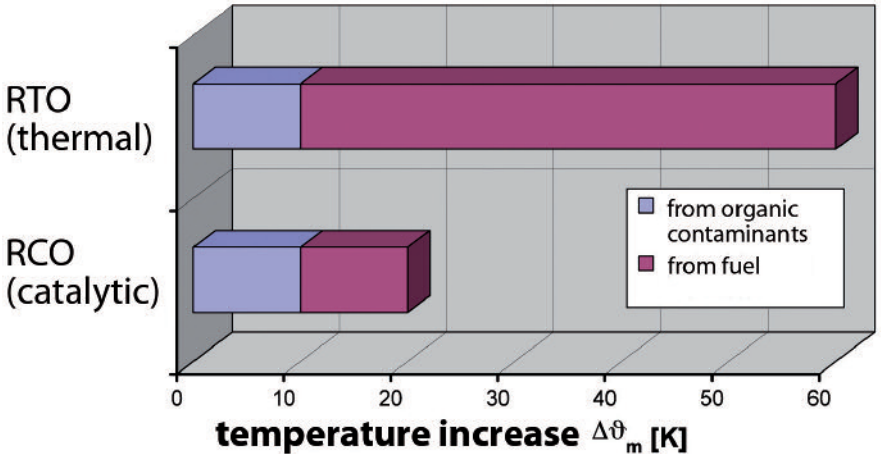

Fig. 2 Comparison of fuel consumption in RTO and RCO mode (same regenerator size)

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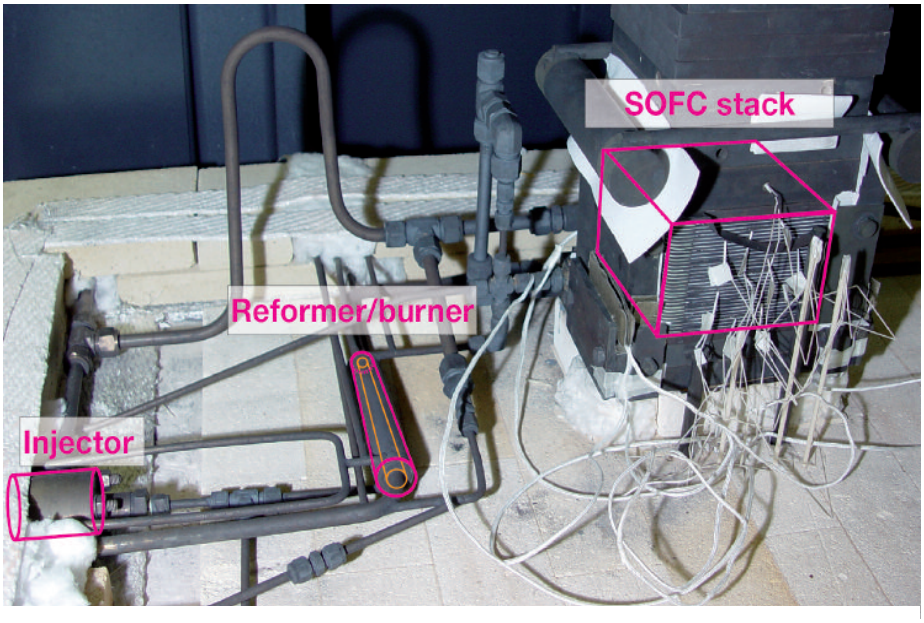
FOLLOW-ON PROJECT FOR DEVELOPMENT OF AN SOFC SYSTEM WITH ANODE OFF-GAS RECYCLING



Complete system built in the CUTEC test bed oven

The Chemical Process Engineering Dept. has been working intensively on the development of high-efficiency, high-temperature Solid Oxide Fuel Cell (SOFC) technology since 2003. The main emphasis is not on development of the actual fuel cell stack, but rather on maximization of system efficiency by improving the components and providing intelligent interconnect of the individual process stages .

One example of innovative system design was developed during a joint research project which was carried out between 2007 and 2009. In collaboration with the Fuel Cell Research Center (ZBT Duisburg), the Institute for Heat and Fuel technology (IWBT, TU Braunschweig) and the Electrical Power Engineering Institute (IEE) at TU Clausthal, a lab-scale fuel cell system was built at the CUTEC Institute, which uses anode gas released by the fuel cell rather than water or air (as it is usually the case) for reforming the propane fuel. This leads to a significant increase in overall electrical efficiency and to a more efficient and eco-friendly electricity supply. The project received funding from the German Ministry of Economics and Technology (BMWi), and it was successfully completed at the end of 2009. The project demonstrated an increase in electrical efficiency from around 27 % to 40 % (based on the lower heating value of the propane). The illustration above shows the complete system on the CUTEC test bed containing the three main subsystems: the SOFC stack, the reformer/burner unit and hot gas injector.

Based on the project success and the new issues which were identified, the project team submitted a follow-on application to AiF for the purpose of developing the concept to the autonomous stage (no dependency on the test bed environment). To achieve that goal, substantial improvements will have to be made to the individual subsystems (reformer/burner, hot gas injector and SOFC stack).

AiF was favourably impressed with the application, and the funding was approved. The research institutes have been working on further development of the technology since July 2010. Significant advances have been made in stack design in recent years, and the project team got access to the latest commercially available stack generation (Staxera MK200, see illustration at the right). To ensure that the SOFC system delivers sufficient electrical power to meet market needs, the project team decided to integrate two stacks into the system to generate an electrical power of around 1kW. The project team is receiving additional engineering support from companies which are represented on the industrial Steering Committee. Besides Staxera, the list of high-profile industrial partners also includes Robert Bosch, Siemens and Vaillant. Small and medium-sized enterprises take part in the project as well, and their material and personnel support would be welcome. The Steering Committee now has eleven members.

The main role allocated to CUTEC on the project is the integration of new stacks into the overall system design and continued development of the hot gas injector. The injector returns the anode gas, which exits the stack at around 850 °C, to the reformer, and finding the right solution is a very significant engineering challenge. ZBT is working on an improved reformer/burner unit. Using a dynamic process model of the overall system developed by IWBT, the team is investigating how the system can be expected to respond under all operating conditions. IEE will then use the process model to develop the control and operational management strategy. Finally, all of the components will be merged at CUTEC to build the complete system which will then be put into operation and studied in detail. That is planned for the middle of 2012.

Current MK200 SOFC stack generation, Staxera GmbH, Dresden

Following successful completion of the project, the concept will be further developed to create a basis for producing a marketable system with the aid of industrial partners. Who knows? A few years from now, you could see the results of our research activities in a fuel cell heating system right in your own home. At any rate, you may rest assured that we are working on it. (li)

CAMBI flow-through hydrolysis system at the Amperverband WWTP

PHOSPHATE RECOVERY

Skilful combination of energy efficiency and resource efficiency

As the cost of disposing biosolids from waste water treatment plants (WWTP) continues to rise, there is an increasing need for new techniques to reduce sludge volumes (sludge disintegration). However, intensification of the anaerobic digestion process results in increased release of nitrogen (N) and phosphorus (P), resulting in plant performance problems and higher N and P loading in the plant. The goal of a research project, which was funded by the German Environment Foundation (DBU) and carried out in collaboration with the Hamburg-based firm P.C.S., was to find ways of overcoming the drawbacks associated with improvements in the anaerobic digestion process while at the same time increasing the phosphorus and nitrogen recovery rate.

The first step was to study the influence of thermal hydrolysis (Cambi process, see illustration above) on the energy equation and the material flows at a WWTP and determine the effects on the plant's energy and cost structure. Another major emphasis was optimisation of nutrient recovery from concentrated digestate using the Cambi process. Specifically, that entailed phosphate precipitation and crystallisation in the form of struvite (MAP) and the recovery of ammonium hydroxide by steam stripping.

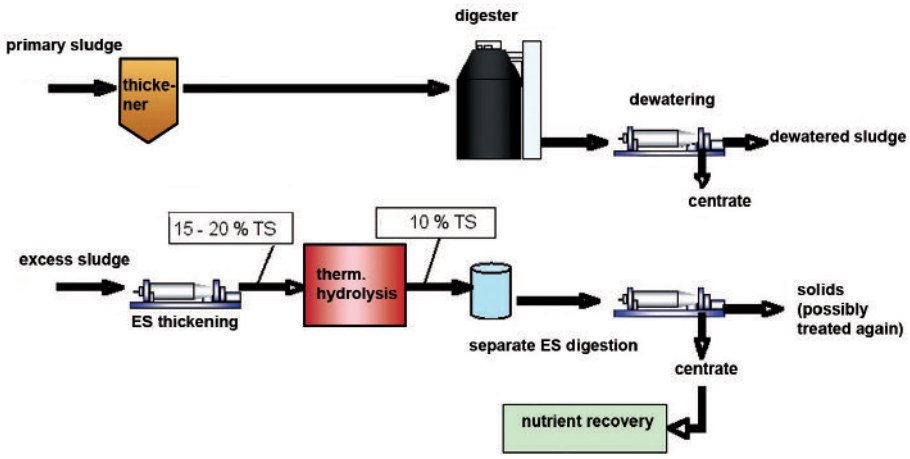
Based on the results of these investigations, the project team developed a conceptual approach which they then evaluated based on the energy and material equations and on an estimation of the investment and operational costs. The proposed process consists of separate hydrolysis of excess sludge and separate anaerobic digestion of the hydrolysed sludge (see illustration below). The formation of high nutrient concentrations in a small volume of process water creates favourable conditions for nutrient recovery.

Thermal hydrolysis trials on thickened excess sludge resulted in roughly a 50 % COD* decomposition rate, and around 40 % of the phosphorous content of the sludge was redissolved. Thermal hydrolysis also reduced sludge viscosity by roughly 90-95 %. Due to these effects, methane production increased by around 50% during continuous trials with excess sludge compared to untreated sludge. The concentrations of dissolved nutrients in the sludge liquor were greater than 800 mg/L PO4-P** and 2,300 mg/L NH4-N***. Because of these higher concentrations, significantly lower amounts of precipitants and chemicals were needed during the P and N recovery trials, making a further contribution to resource conservation.

The volume of process water that required treatment was reduced to about one quarter of the original volume, significantly reducing plant size (investment cost, material consumption) and the amount of energy consumed for process water treatment.

Summary: The combination of thermal hydrolysis with P and N recovery based on the conceptual approach which the project team has developed produces a number of benefits at a WWTP: reduction in ventilation energy, increased digester gas production and electricity generation at the plant, increased digester and basin volume capacity, improved sludge dewatering, reduction in the amount of organic matter needed for denitrification, utilisation of the excess organic material to increase digester gas production, more capacity for increased biological phosphorus elimination (Bio P) and reduction in use of precipitates for phosphorus precipitation.

The project demonstrated a method for combining resource conservation with a significance increase in energy efficiency. With this approach, it is possible to operate a WWTP much more efficiently and expand purification capacity. There may also be cost benefits depending on local circumstances, and it might be helpful to confirm the findings in a demonstration project. An application for additional funding should be submitted and WWTP operators, who use a Bio P or partial Bio-P process at their plant and are interested in this approach, are cordially invited to participate. (si)



Proposed process for separate excess sludge treatment

COD*: Chemical Oxygen Demand / PO4-P**: phosphorus from phosphate / NH4-N***: nitrogen from ammonia

I M P P R I N T

Published by:
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Editor: Dr. T. Heere (he)
Contributors:
Prof. Dr.-Ing. O. Carlowitz (ca)
Dipl.-Ing. K.-H. Dammeyer (da)
Dipl.-Ing. R.-U. Dietrich (di)
Prof. Dr.-Ing. H. Horn (ho)
Dr.-Ing. B. Kragert (kra)
Dr.-Ing. A. Lindermeir (li)
Dipl.-Ing. W. Siemers (sie)
Prof. Dr.-Ing. M. Sievers (si)
Layout and typesetting:
G. Wessels (wes)
Photos: Gert-E. Knochen
Production and supply:
CUTEC-Institut GmbH
Leibnizstr. 21+23
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3RD LOWER SAXONY FUEL CELL SUMMER SCHOOL – A REVIEW

Summer School participants in great form following a week of learning and fun

The Fuel Cell Summer School organised by the **Fuel Cell and Electromobility State Initiative of Niedersachsen** CUTEC and the TU Clausthal Environmental Science Institute was held for the 3rd time this year. This year's event took place at the "House of Science" in Braunschweig in collaboration with Prof. Leithner from the Braunschweig Heat and Fuel Institute who hosted the proceedings. Battery technology was added to the Summer School curriculum for the first time, reflecting the new direction taken by the State Initiative.

Companies such as EWE, IAV, H.C. Starck and Volkswagen actively supported the event which now attracts attention nationwide. The universities in Braunschweig, Clausthal, Hannover and Oldenburg on the academic side also made a big contribution.

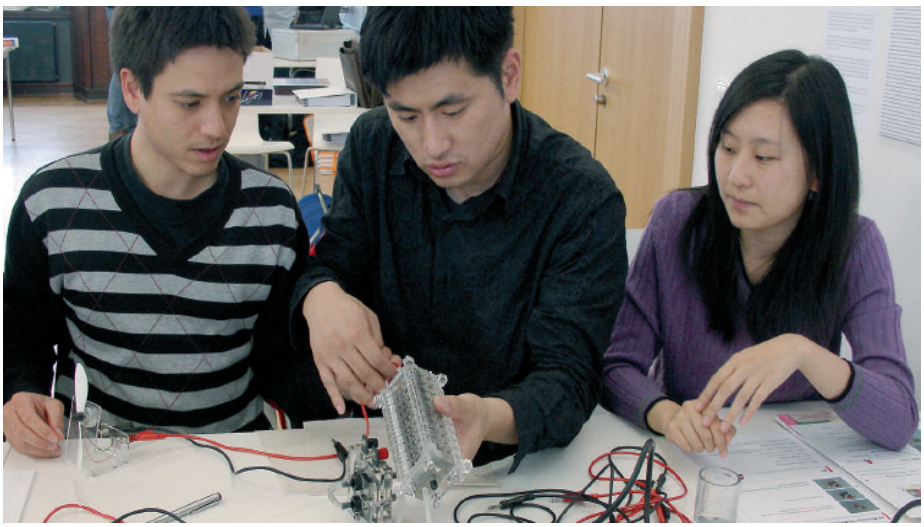
50 students and PhD candidates booked up all of the available places at the Summer School. A few of the course participants travelled from as far away as Mannheim, Regensburg and Stuttgart to attend. It appears that word about the quality and the great atmosphere at the Summer School is spreading, and the reaction following a week of lectures, practical exercises, discussions and preparation of presentations was unanimous and very emphatic: "fantastic work by all of the organisers and sponsors, great lectures covering a wide range of topics, very good mix of information from the research and industrial communities."

Scientists of Lower Saxony explained the scientific basis of PEM, DMFC and SOFC fuel cells including electrochemistry, thermodynamics, materials, components, subsystems and systems: Prof. Leithner and Prof. Schröder (TU Braunschweig), Dr. Conrad (Next.Energy), Prof. Caro (University of Hannover), Dr. Dörrer, Prof. Kunz and Prof. Turek (TU Clausthal) and Dr. Lindermeir (CUTEC). In addition, Prof. Wenzl (TU Clausthal) and Dr. Wilkening (University of Hannover) provided a basic introduction to battery technology.

Experts from local companies including Mr. Barth (EWE AG), Dr. Otterstedt (H.C. Starck), Mr. Meinel (I+ME Actia), Dr. Antonius (Johnson Controls), Dr. Klein, Dr. Schmitz and Dr. von Unwerth (Volkswagen) and Dr. Hickmann (W. Eisenhuth GmbH) outlined the practical issues. Some of the speakers travelled to the event from Baden-Württemberg (Dr. Jungmann, Fraunhofer ISE), Hamburg (Mr. Klose, Baxi Innotech), North-Rhine Westphalia (Mr. Lohren, Ceramic Fuel Cells), and Saxony (Mr. Strohbach, Staxera GmbH). Mr. Dietrich (CUTEC) gave an update on current research projects.

Lübeck University of Applied Sciences (Dr. Hamelmann) provided opportunities for practical experimentation on fuel cells and electrolysers (with the support of the Lübeck-based firm Firma h-tec). The agenda also included excursions to VW's research centre in Isenbüttel and to the Chemical Process Engineering Institute and CUTEC in Clausthal for practical courses on their test beds. The course participants prepaired their own presentations describing the nature of the trials and drawing some conclusions from the results achieved.

After a week of learning more about the basic scientific principles, listening to reports on current research and taking part in practical experimentation, each of the course participants had a clearer idea of whether they might choose fuel cell and battery technology as their future area of specialisation. Lower Saxony is leading the way by giving young members of the academic community a greater insight into technology which will play a major role in the Fuel Cell and Electromobility State Initiative of Niedersachsen and by providing an avenue of contact with scientists and industry. The course participants thoroughly enjoyed this event which is definitely "to be continued". The 2011 Summer School is planned to take place at EFZN in Goslar. Preparations will soon be getting underway. (di)



Hands-on experiments reinforce learning and promote teamwork

SCIENTIFIC ADVISORY BOARD

A profile of Prof. Harald Horn

Prof. Harald Horn

After studying chemical engineering at the University of Applied Sciences in Münster (1978-1982) and the University of Kassel (1988-1991), Prof. Horn received his doctorate from the University of Kassel in 1995. The topic of his thesis was quantitative measurement and modelling of substrate turnover and flow rates in biofilm systems. From 1996 to 2005, he was Professor of Hydro and Solid Waste Chemistry at the University of Applied Sciences in Magdeburg-Stendal. He spent the winter semester 01/02 as Visiting Professor at the University of Illinois in Urbana-Champaign. In 2003, he wrote his post-doctoral thesis at the University of Applied Sciences in Braunschweig on the modelling of substrate turnover and flow rates in biofilm systems, and in 2005 he was appointed Professor of Sanitary Engineering at the University of Applied Sciences in Munich.

Harald Horn's teaching and research activities are concentrated on environmental biotechnology. He focuses primarily on creating a link between fundamental chemical and biological processes and practical engineering applications in wastewater treatment, water quality management, effluent treatment and re-use. (ho)

Continuation from page 3

CAT AND MOUSE?

systems. The engineering risk on the projects essentially stems from the threat of catalyst deactivation. The root cause for this could be thermal, mechanical or chemical (e.g. sintering or dust). The list of typical catalyst poisons includes organosilicon compounds as well as chlorine and sulphur compounds. The overall business risk stems from the engineering risk. Guarantees that emission control levels will be maintained for a minimum period will have to be provided on RTO to RCO retrofit projects.

Economic necessity and ecological advantages

The primary target group is non-autothermic RTO plants. There are around 1,800 of these plants in Germany, which have a mean rated off-gas capacity of 20,000 m^3/h. Most operate in three shifts roughly 220 days a year. If you compare the annual reduction in energy costs with the cost of the retrofit, it turns out that the expected payback period is roughly one and three-quarters years.

Continued use of existing systems is another economic aspect to consider. In many cases, thermal RTOs have sufficient residual value to justify an RCO retrofit. Heat exchangers and combustion systems are normally made completely of ceramics, so they are extremely durable, and most of them have not reached the end of their lifecycle after 10 – 15 years Depending on size, the cost of a new RTO is in the 400,000 – 550,000 euro range. A retrofit costs only a third as much.

There is also the ecological aspect to consider. Since most RTOs are not coupled to the production process via a heat transfer medium (e.g. steam) and are used exclusively to control emissions, a reduction in fuel consumption leads to a proportional net reduction in CO_2 emissions. Given the size and number of RTOs out there, the expected annual reduction in CO_2 emissions is in the neighbourhood of 656,000 t.

Market introduction

Upon project completion, the intention is to roll out the new engineering service. RCO retrofit is a very attractive option for the user, because the payback period is short, the risk is limited and there is no need for new systems. This is no "cat and mouse game". The objective is to make an important contribution to energy efficiency and to protect the environment by reducing CO_2 emissions. (da)

Green Talents at CUTEC

Award-winning young scientists take a tour of Germany

"Sustainability can only effectively move forward on a global scale. Providing support to top scientists from around the world is vital to success," said Prof. Schavan as she presented the awards to this year's winners of the Green Talents competition at the 7th Sustainability Forum in Berlin. The event, which is sponsored by the Ministry of Education and Research (BMBF), was held on November 4th. 20 young scientists from around the world received awards for their outstanding research on sustainability. The young researchers then had the opportunity to pay a visit to leading sustainability research organisations. CUTEC, TU Clausthal (Prof. Goldmann) and the Energy Research Centre of Lower Saxony (Prof. Schade) were among the stops on the itinerary. While at CUTEC, the visitors had a look at the steel-dezincification pilot plant which is part of a steel scrap recycling project funded by BMBF. At the same time our partner Prof. Gock (TU Clausthal) gave a talk on this highly successful project at the above-mentioned BMBF Sustainability Forum in Berlin. This platform gives experts the opportunity to intensify international cooperation, and it encourages innovation in the field of climate and resource protection. (kra)

CUTEC CONTINUES DIALOGUE WITH MEMBERS OF THE LOWER SAXONY PARLIAMENT

State delegates and CUTEC share information on environmental policy and technology

Both sides share the goal of promoting the interests of Lower Saxony. Energy was the main item on the agenda when CUTEC and the Environment and Climate Protection Working Group of the Lower Saxony parliamentary parties got together again recently. Led by environmental spokesperson Martin Bäumer, state delegates from the CDU and FDP parties came to CUTEC in October for an information sharing session.

Prof. Carlowitz and his team presented an overview of current research activities in the energy sector including biogas, fuel cells, biomass gasification, Fischer-Tropsch Synthesis and the Clausthal Energy Park. The delegates were visibly impressed with what they saw at CUTEC and understand that leading-edge research is in progress here, which can make a very significant contribution to the solution of current energy and environmental problems. They also promised their continued political support.

In conjunction with their meeting which is scheduled to take place in the region in 2011, the Working Group plans another visit to CUTEC to gather inputs based on the environmental and energy research activities at CUTEC for the public discussion. (kra)

TATAR SCIENTISTS RECEIVE ADVANCED TRAINING AT CUTEC

A group of Russian scientists from the renowned University of Kasan (Rep. of Tatarstan) took part in a training course at CUTEC, which was organised by the German Management Academy of Lower Saxony gGmbH (DMAN). Under the guidance of the Sustainability Management Cluster, individuals from the various departments gave presentations on selected aspects of environment engineering. The guests were highly impressed by the mix of theory and practice which included presentations and visits to the labs and pilot test facilitates. They were particularly keen to learn more about wastewater treatment.

At the request of the delegation's leader, a partnership agreement was signed to foster collaboration in the area of education and research. The first step will be to define areas of shared interests and investigate potential sources of project funding. (kra)

Even stamping something can be productive at CUTEC: Prof. Carlowitz (front left) and Prof. Fridland (front right) signing the partnership agreement

The long walk: on the trail of DBU eco projects

Dr. Lehmal is gathering promotes her project by walking "10,000,000 steps on a DBU tour of Germany". Since 2009, she has been taking people with her on her long walk to visit model ecology projects sponsored by the German Environment Foundation (DBU).

Information is passed along more or less "on the fly". By combining environmental protection, an experience of nature and healthy activity, Dr. Lehmal in her own unique way is helping to enhance the network of people who are actively committed to the environment. She gives people who take part in the journey the opportunity to engage in an intensive dialogue on tomorrow's ecological issues. In October, the Harz region was the third stage on the DBU tour itinerary. In Clausthal, CUTEC provided information on its activities and gave the visitors a glimpse of DBU-funded innovation which assists conservation of our valuable resources. (kra)